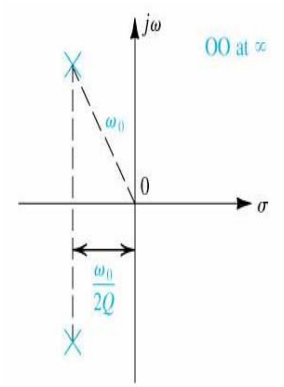
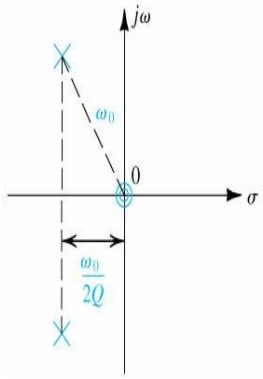
Lect. 16: Second-Order Active Filters (S&S 12.6)

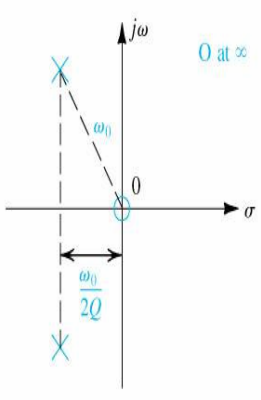
2nd-order filters



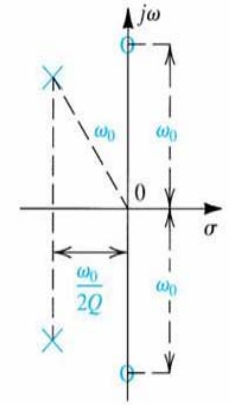
LP



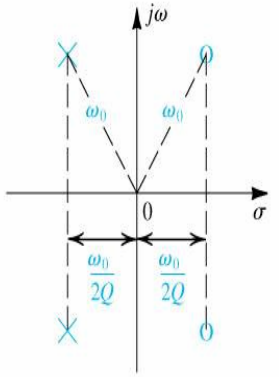
HP



BP

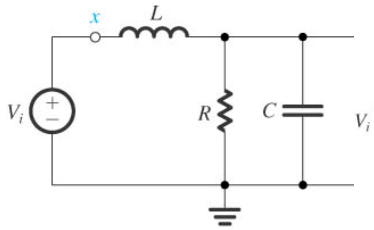


BR

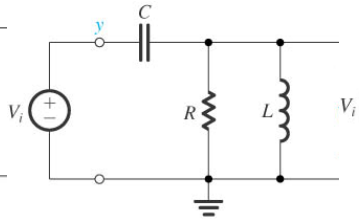


AP

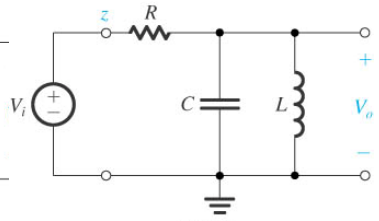
Passive Realization



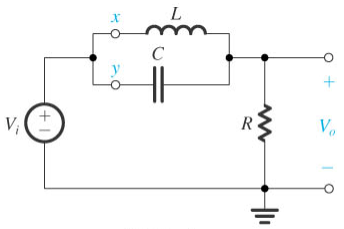
(b) LP



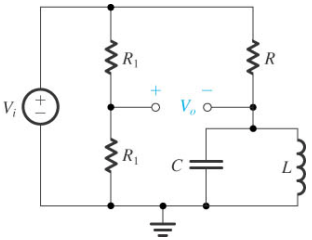
(c) HP



(d) BP

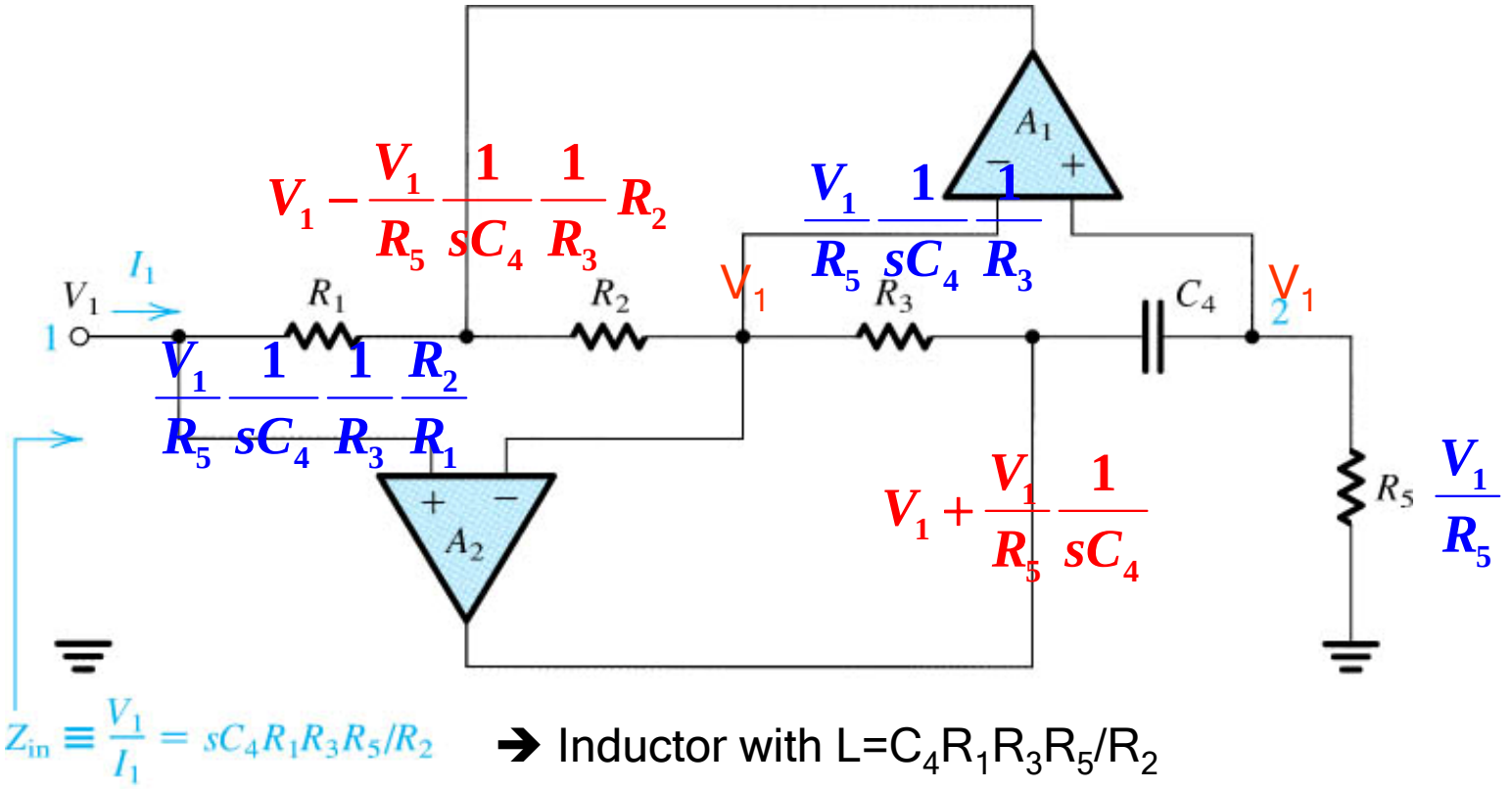


(e) Notch at ω_0



Active Realization? Replace inductor with op-amp circuit

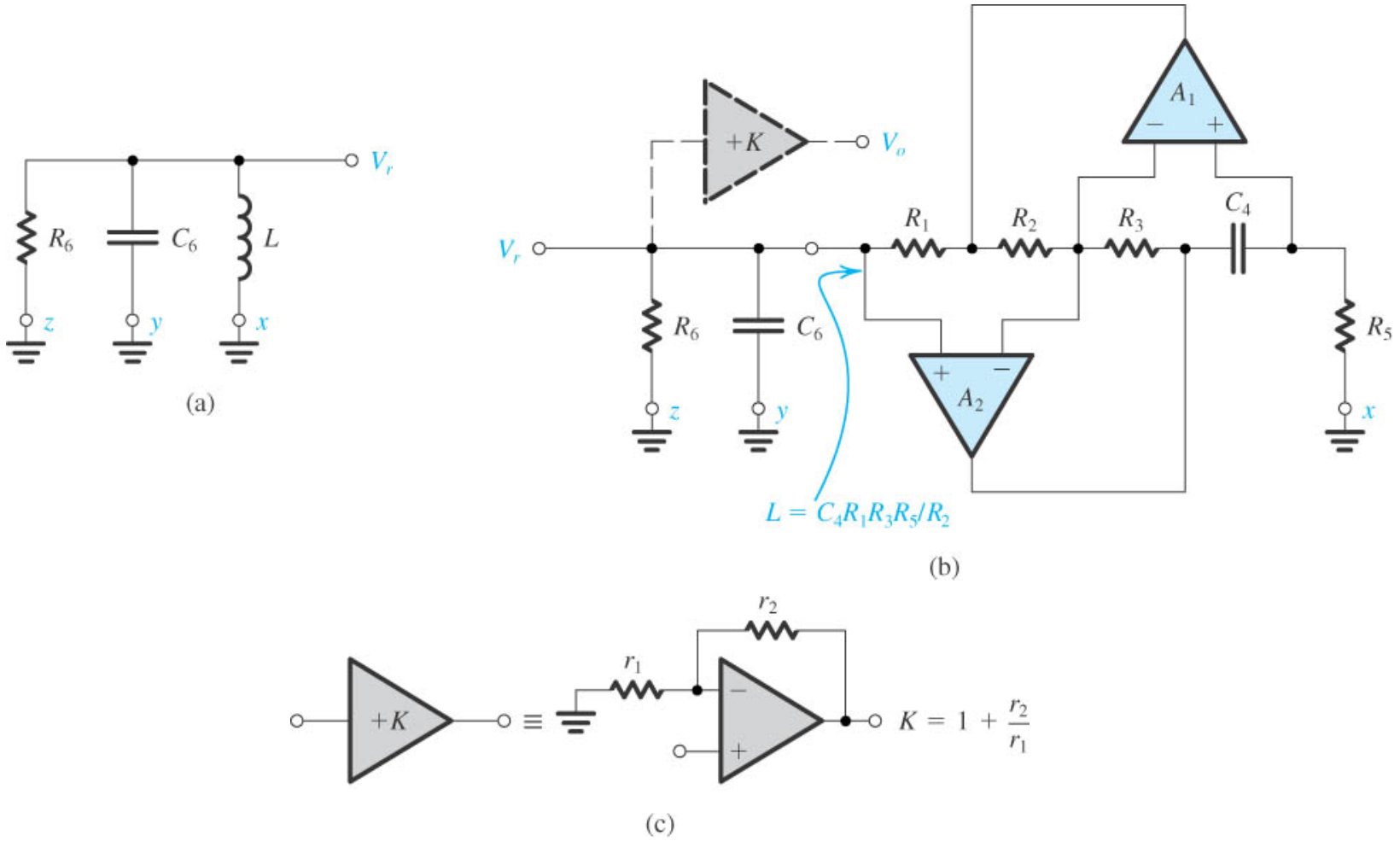
Antoniou Inductance-Simulation Circuit



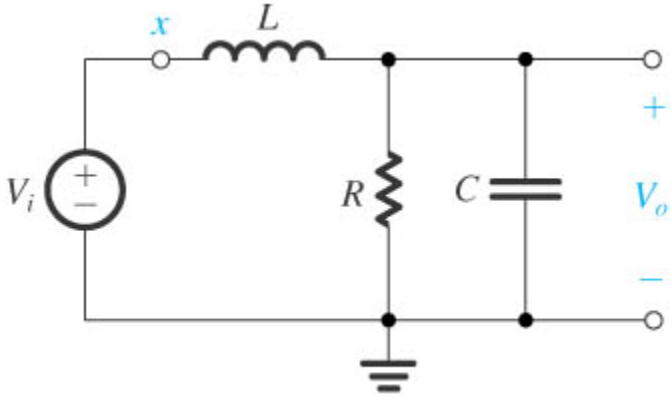
➔ Inductor with $L=C_4R_1R_3R_5/R_2$

(a)

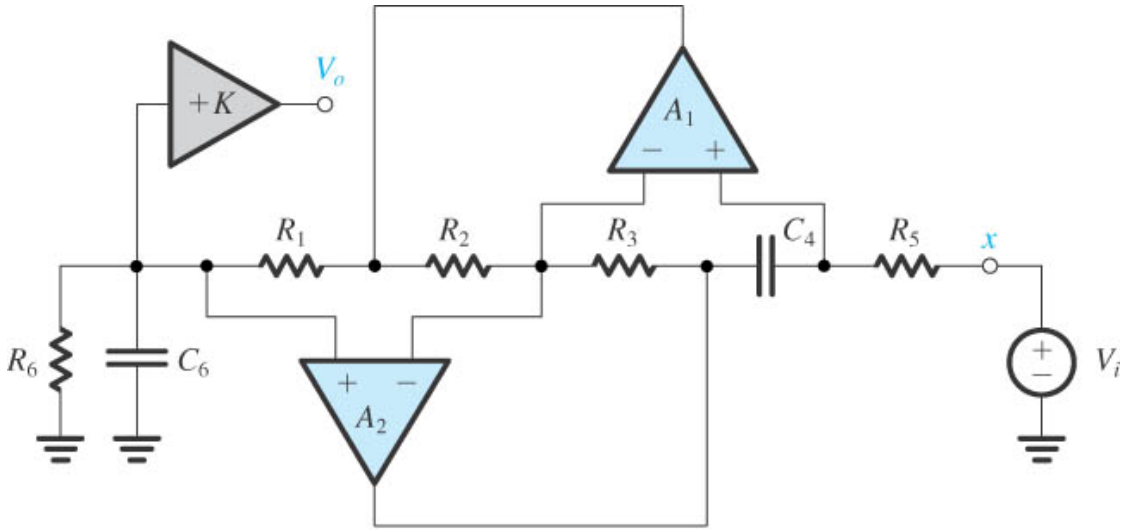
Lect. 16: Second-Order Active Filters



Lect. 16: Second-Order Active Filters



(b) LP



(a) LP

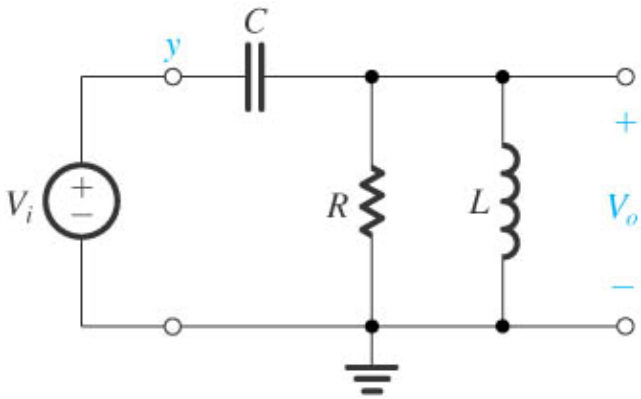
$$T(s) = \frac{\omega_0^2}{s^2 + \frac{\omega_0}{Q}s + \omega_0^2}$$

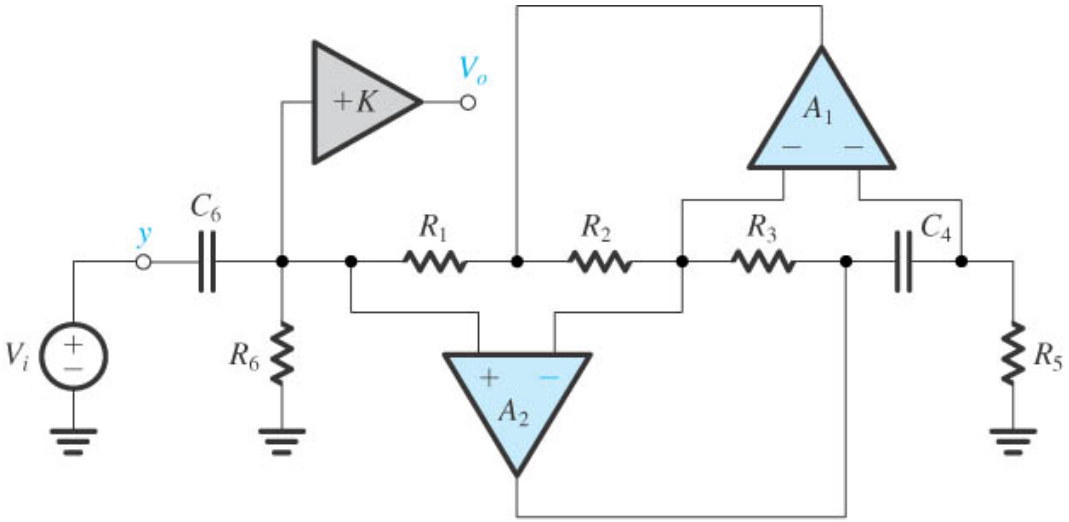
$$\omega_0 = \frac{1}{\sqrt{LC}} \qquad Q = \sqrt{\frac{C}{L}}R$$

➔Replace L with $C_4R_1R_3R_5/R_2$

Multiply K

Lect. 16: Second-Order Active Filters

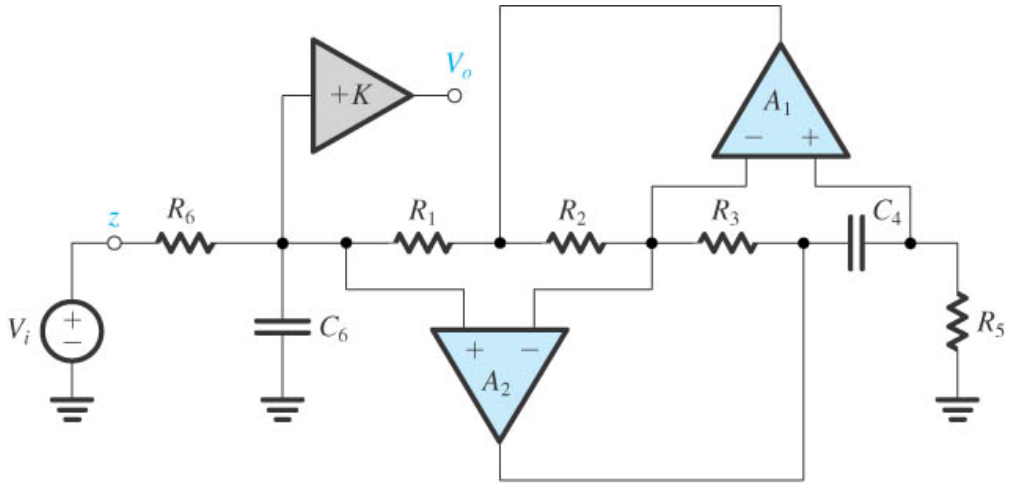




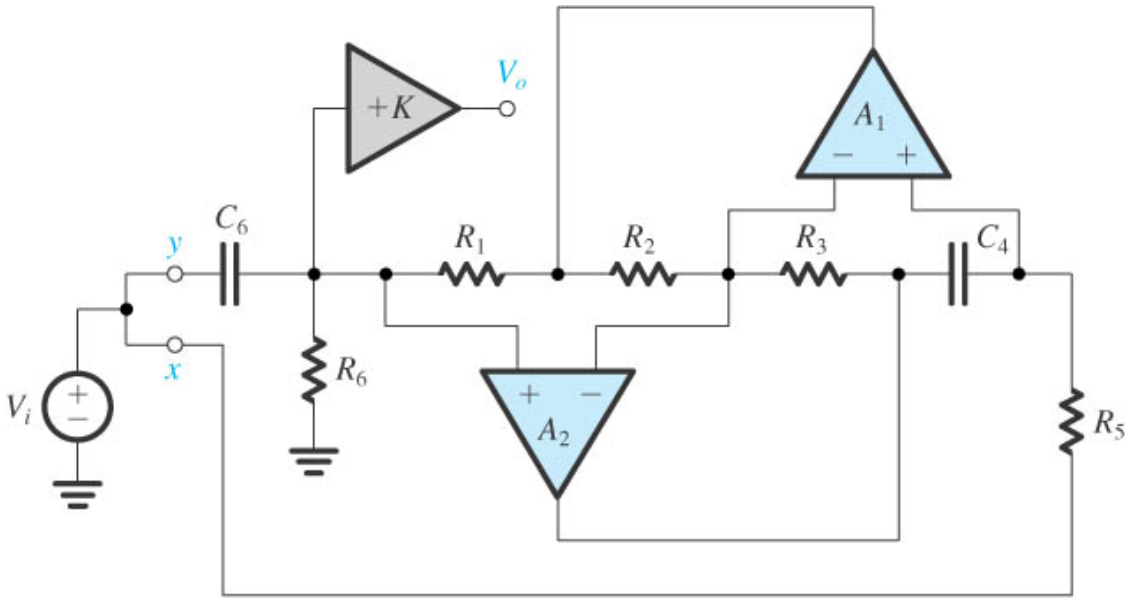
HP Filter

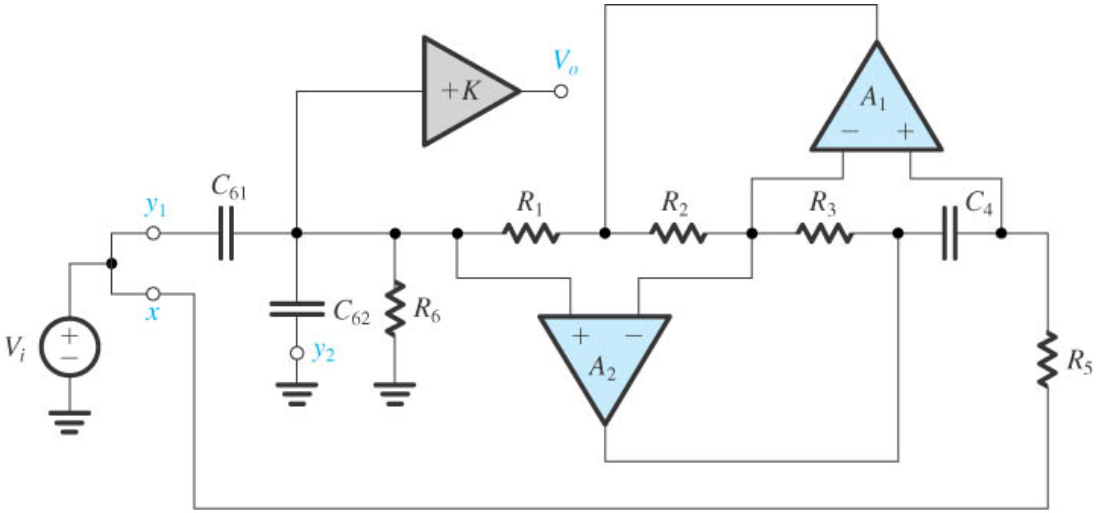
➔Replace L with $C_4R_1R_3R_5/R_2$

Multiply K

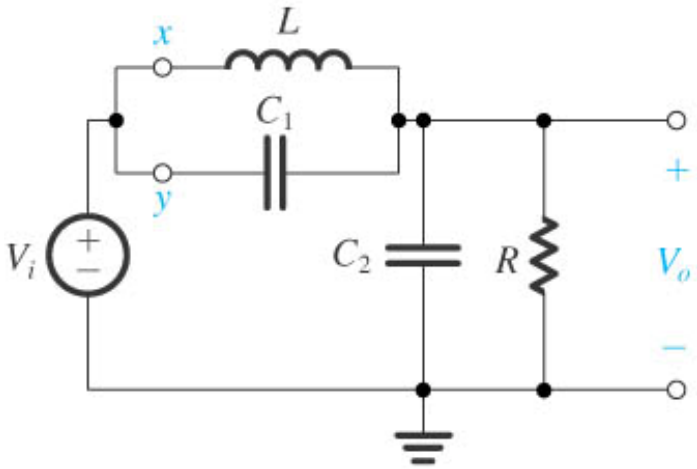

V_o
$+K$
A_1
z
R_6
R_1
R_2
R_3
C_4
V_i
C_6
A_2
R_5

Lect. 16: Second-Order Active Filters



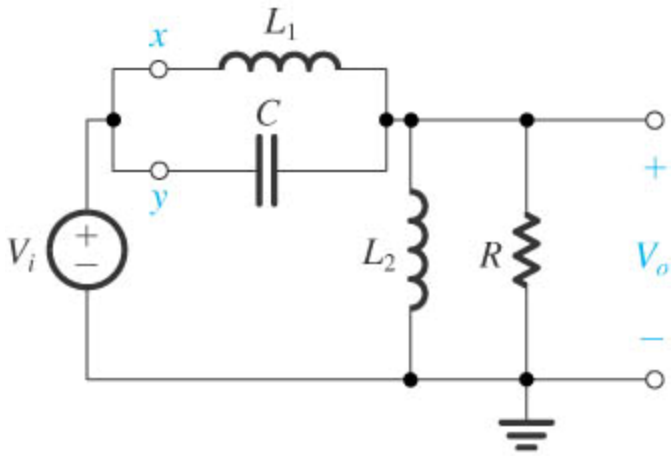


(e) LPN, $\omega_n \geq \omega_0$

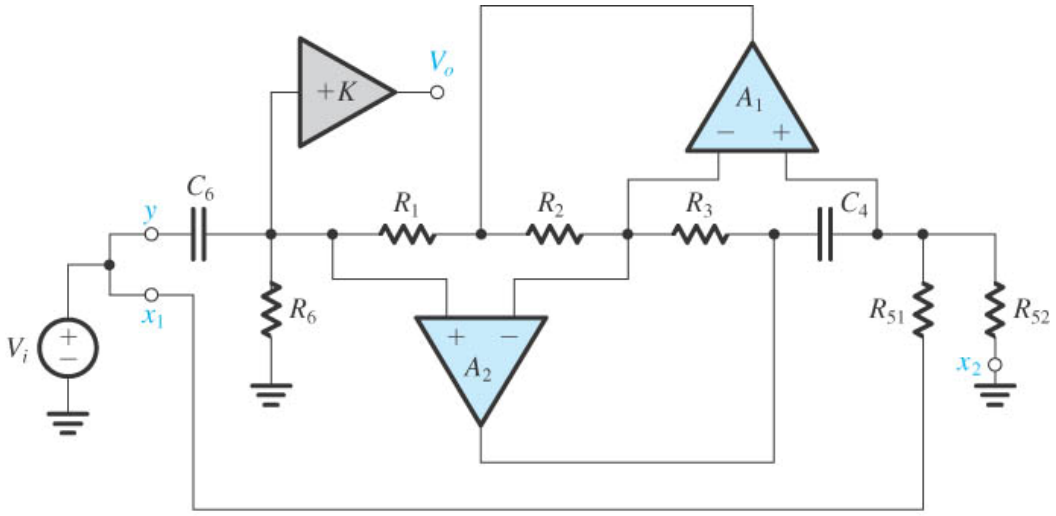


(g) LPN ($\omega_n > \omega_0$)

Lect. 16: Second-Order Active Filters



(i) HPN ($\omega_n < \omega_0$)



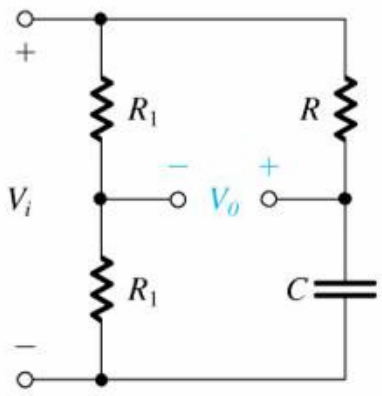
(f) HPN, $\omega_n \leq \omega_0$

$L_1 = C_4R_1R_3R_{51}/R_2$ $\quad$ $L_2 = C_4R_1R_3R_{52}/R_2$

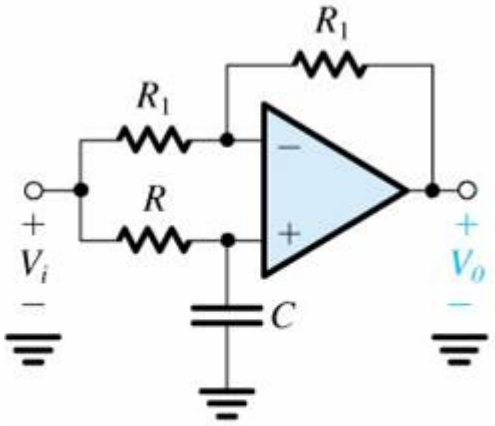
Lect. 16: Second-Order Active Filters

First-Order All-Pass Filter

Remember



$CR = 1/\omega_0$
Flat gain $(a_1) = 0.5$



$CR = 1/\omega_0$
Flat gain $(a_1) = 1$

$$V^+ = V_i \frac{1/sC}{1/sC + R}$$

$$V^- = \frac{V_i + V_o}{2}$$

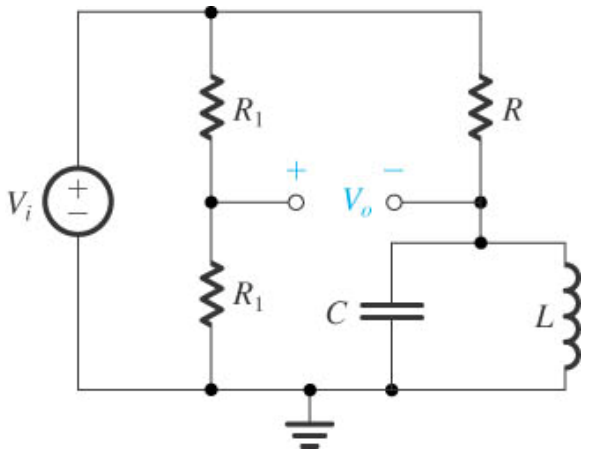
$$V_i \frac{2}{1+sRC} = V_i + V_o$$

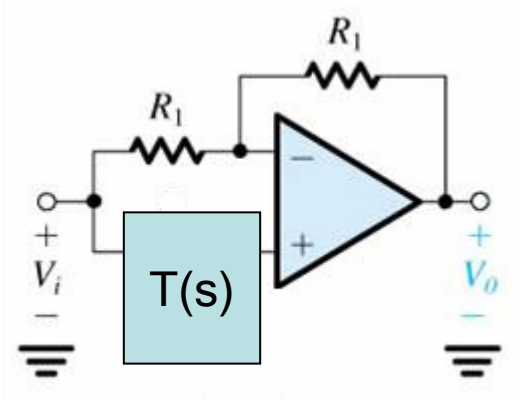
$$V_o = 2V_i\left(\frac{1}{1+sRC} - \frac{1}{2}\right)$$

$$\frac{V_o}{V_i} = -\frac{sRC-1}{sRC+1}$$

Lect. 16: Second-Order Active Filters

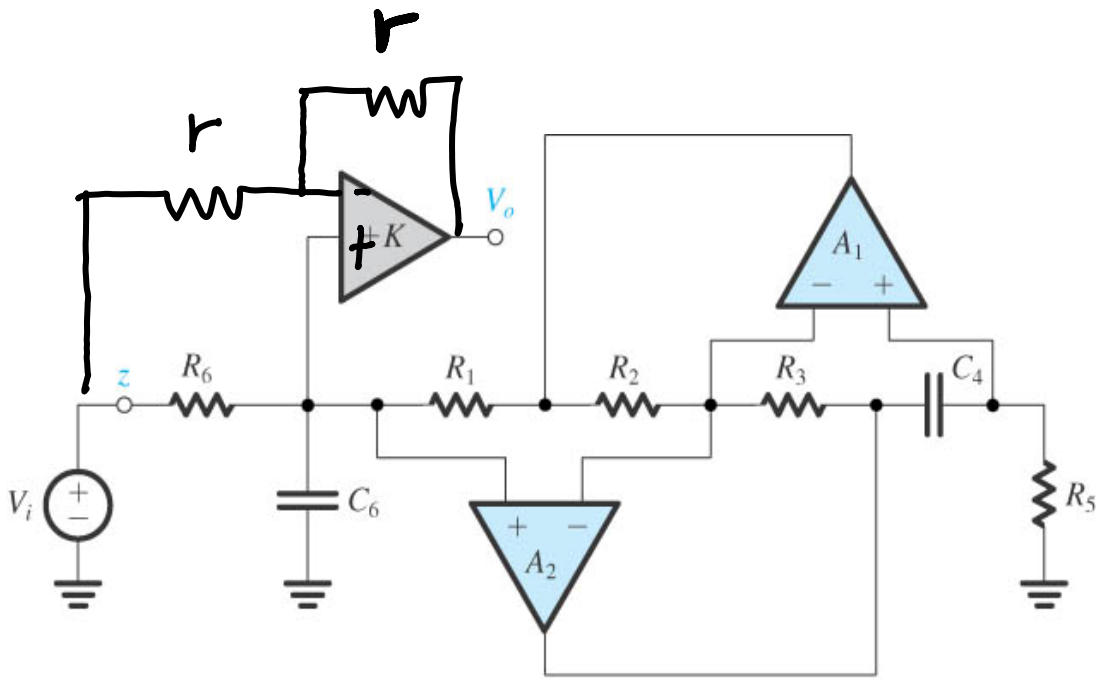
Second-Order All-Pass Filter





T(s): Bandpass Filter

Lect. 16: Second-Order Active Filters



Second-order Bandpass Filter

➔ Second-Order All-Pass Filter